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[List of File Documents]

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[Document Name] SPECIFICATION

[TITLE OF THE INVENTION] METHOD OF MANUFACTURING  
MAGNETIC RECORDING MEDIUM AND MAGNETIC TRANSFER  
APPARATUS

5 [CLAIMS]

[Claim 1] A method of manufacturing a magnetic recording medium,  
comprising:

a first step of preparing a magnetic disk by forming a magnetic layer  
of a ferromagnetic thin film on a disc-shaped substrate;

10 a second step of forming a lubricant on the magnetic disk;

a third step of bringing a magnetic transfer master having a  
magnetic film formed on at least one side into close contact with a surface of  
the magnetic disk at which the magnetic layer is formed and magnetically  
transferring a pattern of the magnetic film of the magnetic transfer master  
15 onto the surface of the magnetic disk through application of an external  
magnetic field; and

a fourth step of burnishing at least the surface of the magnetic disk  
that comes into close contact with the magnetic transfer master,

20 wherein the first step, the fourth step, the second step, the fourth  
step, and the third step are performed in the stated order.

[Claim 2] The method of manufacturing a magnetic recording medium  
according to claim 1, wherein pressing force applied to the magnetic disk in  
a burnishing process performed after the first step is stronger than that  
applied to the magnetic disk in a burnishing process performed after the  
25 second step.

[Claim 3] A method of manufacturing a magnetic recording medium,  
which is a magnetic transfer method, comprising steps of:

bringing a magnetic transfer master having a magnetic film formed  
on at least one side into close contact with a magnetic disk;

30 magnetically transferring a pattern of the magnetic film of the  
magnetic transfer master onto the magnetic disk through application of an  
external magnetic field; and

optically detecting defects on a surface of the magnetic disk,

35 wherein the magnetic transfer step is performed immediately after  
it is confirmed that the number of defects or a size of the defects on the  
surface of the magnetic disk is not greater than a predetermined value.

[Claim 4] A magnetic transfer apparatus, comprising:

contacting means for bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk;

transfer means for magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field; and

defect detecting means for optically detecting defects on a surface of the magnetic disk,

wherein the contacting means and the transfer means perform magnetic transfer immediately after the defect detecting means has confirmed that the number of defects or a size of the defects on the surface of the magnetic disk is not greater than a predetermined value.

[Claim 5] A method of manufacturing a magnetic recording medium, comprising steps of:

bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a surface of a magnetic disk at which a ferromagnetic layer is formed;

magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the surface of the magnetic disk through application of an external magnetic field; and

detecting defects on the magnetic disk by scanning the magnetic disk with a detection head that floats a predetermined distance above the surface of the magnetic disk,

wherein the detecting step is performed after the magnetic transfer step.

[Claim 6] The method of manufacturing a magnetic recording medium according to claim 1, comprising a fifth step of detecting defects on the magnetic disk by scanning the magnetic disk with a detection head that floats a predetermined distance above the surface of the magnetic disk,

wherein the fifth step is performed after the third step.

[Claim 7] The method of manufacturing a magnetic recording medium according to claim 6, wherein pressing force applied to the magnetic disk in a burnishing process performed after the first step is stronger than that applied to the magnetic disk in a burnishing process performed after the second step.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Technical field to which the invention pertains]

The present invention relates to a method of manufacturing a magnetic disk used in hard disk drives or floppy disk drives, particularly a magnetic disk suitable for magnetic transfer.

5 [0002]

[Prior Art]

Currently, magnetic recording/reproduction apparatuses are on a trend toward higher recording densities with the aim of producing small, high-capacity apparatuses.

10 [0003]

A representative magnetic disk drive is a hard disk drive. Hard disk drives with areal recording densities in excess of 10 GBit/in<sup>2</sup> already have appeared on the market, with practical use of drives having an areal recording density of 20 Gbit/in<sup>2</sup> being expected in the next few years due to the rapid technological advancements being made in this field.

[0004]

A major technical factor in the achievement of such high recording densities is the use of magneto-resistive element type heads that not only allow increases in linear recording density but also can reproduce, with a favorable S/N ratio, a signal recorded on a track no wider than a few microns.

20 [0005]

The increases in recording density also have made it necessary to reduce the distance that a floating magnetic slider floats above a magnetic recording medium. This increases the probability of the slider coming into contact with the disk for some causes even while the slider is floating. Such a situation requires recording media to have a further smooth surface.

[0006]

Tracking servo technology used in a head plays an important role in having a head precisely scan a narrow track. A modern hard disk drive that employs such tracking servo technology uses areas where tracking servo signals, address information signals, reproduction clock signals and the like are recorded that are provided on a magnetic recording medium at intervals of a predetermined angle (hereinafter referred to as "preformat recording"), and a drive apparatus detects the position of the head based on these signals that are reproduced by the head at predetermined time intervals, and corrects the head position, so that the head can properly scan

a track.

[0007]

As described above, the servo signals, address information signals, reproduction clock signals, and the like are used as reference signals for having the head properly scan tracks. Hence, high positional accuracy is required when writing (hereafter referred to as "formatting") these signals. In current hard disk drives, formatting is carried out with the recording head being positioned using a dedicated servo apparatus (hereafter referred to as a "servo writer") equipped with a highly precise position detecting apparatus that uses optical interference.

[0008]

However, formatting using the aforementioned servo writer has the following problems.

[0009]

First, recording by a magnetic head is linear recording that basically is made through the relative movement between the magnetic head and the magnetic recording medium. Since it is necessary to record signals on a large number of tracks, preformat recording by a method using a servo writer takes a long time. In order to make manufacturing more efficient, a plurality of expensive, dedicated servo writers are required, making the preformat recording very costly.

[0010]

Secondly, the implementation and maintenance of many servo writers incur a high cost. These problems become more serious as the track density and the number of tracks increase.

[0011]

Hence, a method has been proposed that does not use servo writers to carry out formatting. With this method, a disk called a "master" on which all of the servo information has been pre-recorded is placed on top of the magnetic disk to be formatted and energy to achieve transfer is applied from an external source to transfer all of the master information onto the magnetic disk simultaneously.

[0012]

One example of this technique is the magnetic transfer apparatus described in Publication of Unexamined Japanese Patent Application JP H10-40544A.

[0013]

This publication discloses the following method. A magnetic portion made from a ferromagnetic material is formed on a substrate surface in a pattern corresponding to information signals, thereby producing a master information carrier. The surface of this master information carrier is brought into contact with the surface of a sheet-shaped or disc-shaped magnetic recording medium provided with a ferromagnetic thin film or an applied layer of a ferromagnetic powder. A predetermined magnetic field is then applied thereto, so that a magnetic pattern having a pattern form corresponding to the information signals formed on the master information carrier is recorded on the magnetic recording medium.

[0014]

[Problems to be solved by the invention]

In recording information signals using such a conventional magnetic transfer apparatus, the above method is used in which all the arrangement of patterns corresponding to the information signals on the master information carrier is recorded onto the magnetic recording medium as magnetic patterns simultaneously. In this method, however, it is important to have the high density information signals recorded uniformly and with high stability across the entire surface of the magnetic recording medium.

[0015]

In the above-mentioned conventional magnetic transfer apparatus, however, when unwanted protrusions or foreign matter are present between the magnetic recording medium and the master information carrier, depressions appear in the surface of the magnetic recording medium due to the contact between the two.

[0016]

FIG. 12 shows a surface shape of a magnetic recording medium after the magnetic recording medium and master information carrier are brought into contact with each other and magnetic transfer is carried out according to a conventional magnetic transfer method. The circle marked at the center shows a depression formed by an unwanted protrusion. FIG. 13 shows a graph produced by measuring a cross-section of this depression.

[0017]

In FIG. 13, it can be seen that the depression has a depth of about 50 nm from the surface of the magnetic recording medium, and is surrounded by a minute protrusion that is about 20 nm high.

[0018]



As described above, a floating magnetic slider generally floats about 20 nm above the surface of a magnetic recording medium. If a magnetic recording medium has protrusions that are about 20 nm high such as one shown in FIG. 12 (13), the magnetic head will come into contact with the magnetic recording medium during the recording and reproduction of data. In such a case, at the instant when this happens, the magnetic head is forced upward, increasing the clearance between the magnetic head and the magnetic recording medium and deteriorating the signal recording/reproduction performance. Also, physical contact between the magnetic head and the magnetic recording medium shortens the life of the magnetic head and can lead to failures of the magnetic recording medium itself.

[0019]

FIG. 14 is a depiction showing results of optical measurements carried out for protrusions on the entire surface of a magnetic recording medium that has been subjected to magnetic transfer by such a conventional magnetic transfer method. It can be seen that a large number of protrusions with a height of 20 nm or higher are present on the surface of the magnetic recording medium.

[0020]

As described above, according to conventional magnetic transfer methods, there are a large number of protrusions present on the magnetic disk after the magnetic transfer. This causes the problems of lower recording/reproduction performance and a shorter lifespan of a magnetic head. If the future movement towards higher recording densities is accompanied by a reduction in the distance that a magnetic head floats above a disk, these problems will become more serious.

[0021]

With the above-mentioned conventional problems in mind, the present invention is intended to achieve highly reliable magnetic transfer that causes no minute protrusion to appear on a magnetic disk.

[0022]

[Means for solving problems]

In order to solve the above-mentioned conventional problems, a magnetic transfer apparatus and a method of manufacturing a magnetic recording medium of the present invention includes: a first step of preparing a magnetic disk by forming a magnetic layer of a ferromagnetic thin film on

a disc-shaped substrate; a second step of forming a lubricant on the magnetic disk; a third step of bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with the surface of the magnetic disk at which the magnetic layer is formed and magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the surface of the magnetic disk through application of an external magnetic field; and a fourth step of burnishing at least the surface of the magnetic disk that comes into close contact with the magnetic transfer master. The first step, the fourth step, the second step, the fourth step, and the third step are performed in the stated order.

[0023]

With this method, unwanted protrusions and foreign matter are not present on the surface of the magnetic disk, and therefore highly reliable magnetic transfer can be achieved.

[0024]

A magnetic transfer apparatus and a method of manufacturing a magnetic recording medium of the present invention, which is a magnetic transfer method, includes steps of: bringing a magnetic transfer master having a magnetic film formed on at least one side into close contact with a magnetic disk; magnetically transferring a pattern of the magnetic film of the magnetic transfer master onto the magnetic disk through application of an external magnetic field; and optically detecting defects on the surface of the magnetic disk. The magnetic transfer method is characterized in that the magnetic transfer step is performed immediately after it is confirmed that the number of defects or a size of the defects on the surface of the magnetic disk is not greater than a predetermined value.

[0025]

The above-mentioned method makes it possible to achieve highly reliable magnetic transfer where no defects are produced in the surface of the magnetic disk by the magnetic transfer.

[0026]

A method of manufacturing a magnetic recording medium of the present invention includes a step of detecting defects on the magnetic disk by scanning the magnetic disk with a detection head that floats a predetermined distance above the surface of the magnetic disk. The method of manufacturing a magnetic recording medium is characterized in that the step of detecting defects is performed after the magnetic transfer

step.

[0027]

The above method can provide a highly reliable magnetic transfer method where no defects are produced in the surface of a magnetic disk by magnetic transfer, and can supply magnetic disks in which no defects are produced in their surfaces.

[0028]

[Mode for carrying out the invention]

The following describes an embodiment of the present invention with reference to the drawings.

(First Embodiment)

The following describes a magnetic transfer apparatus and a method of manufacturing a magnetic recording medium according to the embodiment of the present invention, with reference to FIGS. 1 to 11.

[0029]

FIG. 1 is a flowchart showing steps for manufacturing a magnetic disk, including a magnetic transfer step according to the embodiment of the present invention.

[0030]

First, a magnetic transfer master is described.

[0031]

FIG. 2 is an enlarged view of part of a magnetic transfer master 2 according to the embodiment of the present invention, which is used for explaining the configuration of the magnetic transfer master 2.

[0032]

In FIG. 2, numeral 30 indicates a magnetic film that is used for transferring a magnetic pattern onto a magnetic disk 1. A master information pattern is formed on the magnetic film 30, in a pattern corresponding to the digital information signals to be recorded on the magnetic disk 1. This master information pattern is formed in a magnetic portion made of a ferromagnetic thin film.

[0033]

Various types of magnetic materials such as hard magnetic materials, semihard magnetic materials, or soft magnetic materials can be used for the ferromagnetic thin film. Any material may be used as long as it enables a digital information signal to be transferred and recorded on the magnetic recording medium. As examples, iron, cobalt, or an alloy of iron

and cobalt may be used.

[0034]

In order to produce a sufficient magnetic field for recording regardless of the type of the magnetic disk 1 on which the master  
5 information pattern is to be recorded, the saturation magnetic flux density of the magnetic material should be as high as possible. In particular, for magnetic disks that have a high coercivity in excess of 2000 oersted, or flexible disks with a thick magnetic layer, there are cases where a saturation magnetic flux density of 0.8 tesla or below is not sufficient for  
10 recording to be performed properly. For this reason, a magnetic material with a saturation magnetic flux density of 0.8 tesla or above, or preferably 1.0 tesla or above, is used in general.

[0035]

Numeral 4 indicates radial grooves that are provided on the contact  
15 surface 3 at which the magnetic film 30 of the magnetic transfer master 2 is provided. With respect to the magnetic transfer master 2 with such a configuration, as shown in step ST1 in FIG. 1, washing by a well-known method, for example scrubbing is performed. However, it has been found by experimentation that using a conventional washing method, it is not  
20 possible to remove minute unwanted protrusions in the magnetic film 30 that remain in the contact surface 3 of the magnetic transfer master 2 or minute foreign matter whose sizes range from about 20 to 50 nm. As a method for solving the above-mentioned problem, step ST2 is performed after step ST1. In step ST2, the magnetic transfer master and a cleaning  
25 NiP disk are pressed closely together and separated from each other a predetermined number of times. With respect to step ST2, air is expelled and pumped between the cleaning NiP disk and the magnetic transfer master repeatedly before magnetic transfer is carried out onto the magnetic disk. This makes it possible to keep the surface of the magnetic transfer  
30 master smooth and free from burrs. In addition, foreign matter remaining on the surface of the magnetic transfer master also can be removed without fail.

[0036]

With reference to the drawings, step ST2 is described. FIGS. 5 and  
35 6 are cross-sectional drawings showing the magnetic transfer apparatus according to the present embodiment. In these drawings, numeral 2 indicates the magnetic transfer master and numeral 1 denotes the magnetic

disk. FIG. 5 shows the state where the magnetic transfer master 2 and the magnetic disk 1 are separated from each other, and FIG. 6 shows the state where the magnetic transfer master 2 and the magnetic disk 1 are in close contact with each other.

5 [0037]

In these drawings, step ST2 is performed with a cleaning NiP disk being placed instead of the magnetic disk 1.

[0038]

10 Numeral 5 indicates a boss that is fixed to the center portion of the magnetic transfer master 2. Numeral 6 is a support for supporting the cleaning NiP disk. A through hole 7 is provided in the center of the support 6 to allow the passage of air. Numeral 8 indicates a passage used for expelling air from between the magnetic transfer master 2 and the cleaning NiP disk or pumping air between them. Numeral 9 indicates an air  
15 exhaust outlet for allowing the air to be expelled from the passage 8. Numeral 10 indicates a suction pump that is connected to the air exhaust outlet, and numeral 11 indicates an exhaust valve that controls the expulsion of air. Numeral 12 indicates an air supplying pump for pumping air into the passage 8, and numeral 13 indicates an air supplying valve for  
20 controlling the supply of air.

[0039]

Numeral 14 indicates a holding arm that holds the magnetic transfer master 2. This holding arm 14 is fixed to the magnetic transfer master 2. The holding arm 14 is positioned to be slidable in the vertical  
25 direction by a guide member 16 supported with a boss portion formed at the top of the holding arm 14.

[0040]

Next, the steps of expelling and pumping air are described in detail with reference to FIGS. 5 and 6.

30 [0041]

First, the step of separation caused by the pumping of air is described with reference to FIG. 5.

[0042]

35 The air supplying pump 12 is operated with the exhaust valve 11 closed and the air supplying valve 13 open, so that air flows into the passage 8. As a result, air is pumped through the through hole 7 upward as shown by the arrow A in FIG. 5. The air that is pumped through the through hole

7 presses the boss 5 upward. Further, air is pumped into the grooves 4, as shown by the arrows B. The air that is pumped into the grooves 4 spreads out radially towards the outer circumference from the center of the magnetic transfer master 2 through the grooves 4. The air then passes through the gap between the magnetic transfer master 2 and the cleaning NiP disk from the grooves 4 and escapes to the atmosphere. This flow of air allows any minute foreign matter that is adhering to the surface of the magnetic transfer master 2 or the cleaning NiP disk to be removed to the outside with the air.

[0043]

During this operation, it is preferable for the gap between the cleaning NiP disk and the magnetic transfer master 2 to be set as narrow as possible. In the present embodiment, the gap is set at about 0.5 mm. This increases the speed at which air flows between the cleaning NiP disk and the magnetic transfer master 2, ensuring that minute foreign matter present between them is removed to the outside.

[0044]

In the present embodiment, the distance between the cleaning NiP disk and the magnetic transfer master 2 is controlled by having the upper surface of the holding arm 14 touch the lower surface of the guide member 16 just when the magnetic transfer master 2 together with the holding arm 14 has risen by 0.5 mm from the positions they hold when the cleaning NiP disk and magnetic transfer master 2 are pressed together.

[0045]

Next, a step of pressing the cleaning NiP disk and magnetic transfer master 2 together through suction is described with reference to FIG. 6.

[0046]

The air supplying pump 12 is stopped and the air supplying valve 13 is closed. As a result, the holding arm 14 to which the cleaning NiP disk is attached moves downwards by its own weight, and thereby it is placed on the cleaning NiP disk with the boss 5 engaging the center hole of the cleaning NiP disk. After this, the exhaust valve 11 is opened and the suction pump 10 is operated.

[0047]

Due to the above operations, air is expelled through the through hole 7 downwards as shown by the arrow C in FIG. 6. The air in the grooves 4, which is to say the air in the space A, also is expelled through the gap

between the center hole of the cleaning NiP disk and the boss 5.

[0048]

As shown in FIG. 7, the grooves 4 are not formed to reach the outer circumference of the magnetic transfer master 2. Hence, in the doughnut-shaped portion in its outer circumference, the magnetic transfer master 2 and the cleaning NiP disk are pressed together throughout the entire circumference. The space A is in the closed state, and the air pressure therein falls below atmospheric pressure. Therefore, the cleaning NiP disk is pressed onto the magnetic transfer master 2 by atmospheric pressure 15.

[0049]

As a result, foreign matter present on the cleaning NiP disk is sandwiched between the cleaning NiP disk and the magnetic transfer master 2. When the cleaning NiP disk and the magnetic transfer master 2 are compared in hardness with each other, the cleaning NiP disk is manufactured using a softer material than the magnetic transfer master 2. Hence, foreign matter that is sandwiched between them sinks into the cleaning NiP disk or causes depressions in the cleaning NiP disk, without damaging the surface of the magnetic transfer master 2. Minute unwanted protrusions present in the magnetic transfer master 2 are also flattened when the magnetic transfer master 2 is pressed against the cleaning NiP disk.

[0050]

The repetition of the operations described above makes it possible to keep the surface of the magnetic transfer master 2 smooth and free from burrs and to securely remove foreign matter remaining on the surface of the magnetic transfer master 2.

[0051]

Next, a method of manufacturing a magnetic disk 1 is described.

[0052]

First, as shown in step ST3 (sputtering), a magnetic layer is formed on the surface using a well-known method. With respect to the formation of the magnetic layer, for example, there is a step of providing a magnetic layer on an aluminum substrate by a dry plating method such as a vapor deposition or sputtering method. Conventionally, a method is employed in which the magnetic layer is protected by a step carried out for providing a protective layer on top of the magnetic layer using a dip coating or spin

coating method, or a dry plating method, such as a vapor deposition or sputtering method.

[0053]

Thereafter, tape burnishing is performed in step ST4. This process is described with reference to FIG. 3. FIG. 3 is a drawing showing a step of tape burnishing according to the embodiment of the present invention. In FIG. 3, there are a spindle 55 for rotating the magnetic disk 1, lapping tape 56 for removing protrusions on the magnetic disk 1, and a nozzle 58 for supplying air 57 to press the lapping tape 56 against the magnetic disk 1.

[0054]

In FIG. 3, first, while the magnetic disk 1 is being rotated, air 57 is supplied from the nozzle 58 to press the lapping tape 56 that is moved in the direction shown by the arrow P in the drawing, against the magnetic disk 1. Thus, protrusions on the surface of the magnetic disk 1 are removed. In this case, as the lapping tape 56 used for this burnishing step was used one with an average granular surface roughness of 1.0  $\mu\text{m}$ . The processing pressure at which the lapping tape 56 is pressed against the magnetic disk 1 was set at 400 kPa. This step is able to remove unwanted protrusions that are present on the surface of the magnetic disk 1 after the protective layer is formed.

[0055]

After that, a step of forming a lubricant is performed, which is a well-known technique, as shown in step ST5 in FIG. 1. This is a step of applying lubricant by immersing the magnetic disk 1 in a lubricant solution and then pulling it out at a predetermined speed.

[0056]

Thereafter, a tape burnishing step is repeated, which is shown in step ST6. The configuration of this step is the same as that in step ST4, but the condition of processing pressure is different. That is, in FIG. 3, a processing pressure at which the lapping tape 56 is pressed against the magnetic disk 1 is set at 40 kPa in this case.

[0057]

As described above, the tape burnishing step is performed before and after the step of forming the lubricant. Furthermore, in the latter tape burnishing step, the pressing force applied onto the magnetic disk by the lapping tape is reduced, thereby ensuring that foreign matter present on the surface of the magnetic disk 1 after the formation of the lubricant film can



be removed.

[0058]

It has been found by experimentation that when a magnetic disk 1 is manufactured using the above steps, a magnetic disk can be produced that is suitable for magnetic transfer, with no foreign matter or unwanted protrusions present on the surface of the magnetic disk 1 before magnetic transfer is performed. This is described in detail later with reference to FIG. 11.

[0059]

The following describes steps ST7 and ST8 to be carried out, with reference to FIG. 4. FIG. 4 is a drawing showing steps ST7 and ST8 according to the embodiment of the present invention. In FIG. 4, numeral 60 indicates a clean booth with a configuration in which a filter 61 with a collection efficiency of 99.9999995% for foreign matter with a size of at least 0.01  $\mu\text{m}$  is placed at its top to stop foreign matter with a size of at least 0.01  $\mu\text{m}$  from entering the clean booth. In this clean booth 60, there are provided step ST7 for performing examination as to whether foreign matter is present on the surface of the magnetic disk 1 using an optical examination method, and step ST8 for performing magnetic transfer.

[0060]

First, a loading cassette 62 in which the magnetic disk 1 that has been subjected up to step ST6 (tape burnishing) is contained is placed in the clean booth 60 from the left side of the clean booth 60, in the direction shown by the arrow I.

[0061]

Next, the cleaning robot 69 retrieves the magnetic disk 1 that has been contained inside the cassette 62 and places the magnetic disk 1 onto a spindle 64. Numeral 65 indicates a laser light source, numeral 66 indicates a detector, and number 67 indicates a cover that prevents laser light from escaping to the outside. The laser light source 65 irradiates the magnetic disk 1 that is being rotated by the spindle 64, and scattered light produced thereby is detected by the detector 66. By doing so, foreign matter present on the magnetic disk 1 at least before magnetic transfer is performed can be detected.

[0062]

When the detector 66 finds foreign matter, the magnetic disk 1 is loaded into an "NG" cassette (not illustrated) by a cleaning robot 70.

[0063]

When the detector 66 finds no foreign matter on the surface of the magnetic disk 1, then the magnetic transfer step ST8 is carried out. In order to carry out step 8, the cleaning robot 70 places the magnetic disk 1 on the support 6.

[0064]

As shown in the present embodiment, it is preferable to use a scattered light method as a method of examining the surface of the magnetic disk 1 in step ST7.

10 [0065]

That is, the examination method using the scattered light method is suitable for the detection of foreign matter on the disk surface, and by performing this step immediately before the step of magnetic transfer, the magnetic transfer can efficiently be performed only with respect to magnetic disks 1 on which no foreign matter is present.

[0066]

The magnetic transfer shown as step ST8 is performed next. This is described in detail with reference to FIGS. 5 and 6.

[0067]

20 FIG. 5 is a cross-sectional drawing showing the apparatus that performs step ST8 according to the embodiment of the present invention, and shows the state where the magnetic transfer master 2 and the magnetic disk 1 are separated from each other in the magnetic transfer step. FIG. 6 is a cross-sectional drawing showing the apparatus that performs step ST8 according to the embodiment of the present invention, and shows the state where the magnetic transfer master 2 and the magnetic disk 1 are pressed together.

[0068]

30 In FIG. 5, numeral 1 indicates a magnetic disk, and numeral 2 denotes a magnetic transfer master to be pressed against the surface of the magnetic disk 1.

[0069]

35 Numeral 3 indicates a contact surface of the magnetic transfer master 2 that comes into contact with the magnetic disk 1. The contact surface 3 is provided with grooves 4 that extend radially from the center of the magnetic transfer master 2.

[0070]

FIG. 7 is a drawing showing the contact surface 3 of the magnetic transfer master 2 that comes into contact with the magnetic disk 1. As shown in FIG. 7, the grooves 4 extend radially from the center of the magnetic transfer master 2.

5 [0071]

In the present embodiment, the depth of the grooves is set at about 5  $\mu\text{m}$ . Numeral 5 indicates a boss that is fixed to the center portion of the magnetic transfer master 2. The boss 5 is engaged with the center hole of the magnetic disk 1, and thereby the magnetic disk 1 and the magnetic transfer master 2 are positioned with respect to each other.

10 [0072]

Predetermined gaps 51 (see FIG. 8) are provided between the center hole of the magnetic disk 1 and the boss 5, thereby allowing air to flow between them. Numeral 6 indicates a support for supporting the magnetic disk 1, and a through hole 7 for allowing air to flow is provided in its center.

15 [0073]

Numeral 8 indicates an air duct that expels air from between the magnetic transfer master 2 and the magnetic disk 1 or pumps air between them. Numeral 9 indicates an air exhaust outlet for allowing the air to be expelled from the air duct 8, numeral 10 indicates a suction pump that is connected to the air exhaust outlet, and numeral 11 indicates an exhaust valve that controls the expulsion of air.

20 [0074]

Numeral 12 indicates an air supplying pump for pumping air into the air duct 8, while numeral 13 indicates an air supplying valve for controlling the supply of air. The air supplying pump 12 has a configuration in which a 0.01  $\mu\text{m}$  air filter is provided, so that foreign matter with a size of at least 0.01  $\mu\text{m}$  is not pumped into the air duct 8. Numeral 14 indicates a holding arm that holds the magnetic transfer master 2. The magnetic transfer master 2 is held on the holding arm 14 by air that is sucked through a through hole (not illustrated) provided in the holding arm 14. Numeral 16 is a holder 16 for allowing the holding arm 14 to slide up and down.

30 [0075]

First, the separating method is described with reference to FIG. 5. The air supplying pump 12 is operated with the exhaust valve 11 closed and the air supplying valve 13 open, so that air flows into the air duct 8. As a

result, air is pumped through the through hole 7 upward as shown by the arrow A in FIG. 5. The air that is pumped through the through hole 7 presses the boss 5 upward. Further, the air is pumped into the grooves 4, as shown by the arrows B. The air that is pumped into the grooves 4  
 5 spreads out radially towards the outer circumference from the center of the magnetic transfer master 2 through the grooves 4. The air then passes through the gap between the magnetic transfer master 2 and the magnetic disk 1 from the grooves and escapes to the atmosphere.

[0076]

10 FIG. 9 shows the relationship between the passage of time and the air pressure in the space (hereafter referred to as a "space S") between the magnetic transfer master 2 and the magnetic disk 1 during the above-mentioned operation. In FIG. 9, the air pressure in the space S sharply increases from a pressure of 101.3 kPa after the lapse of about 3  
 15 seconds, and thereafter, a pressure of about 130 kPa is maintained for about one second. This period corresponds to the above-mentioned state where the magnetic transfer master 2 and the magnetic disk 1 are separated from each other.

[0077]

20 Next, a pressing method is described with reference to FIG. 6. The air supplying pump 12 is stopped and the air supplying valve 13 is closed. As a result, the magnetic transfer master 2 moves downwards due to gravity, and thereby it is placed on the magnetic disk 1 with the boss 5 engaging the center hole of the magnetic disk 1. After this, the exhaust valve 11 is  
 25 opened and the suction pump 10 is operated. Consequently, air in the through hole 7 is expelled downwards as shown by the arrow C in FIG. 6. The air in the grooves 4 also is expelled through a gap 51 between the center hole of the magnetic disk 1 and the boss 5, and thus the air pressure in the space of the grooves 4 that are covered with the magnetic disk 1 falls below  
 30 atmospheric pressure. Hence, the magnetic disk 1 is pressed onto the magnetic transfer master 2 mainly by atmospheric pressure 15. In FIG. 9, the period where the air pressure in the space S is about 30 kPa corresponds to the above-mentioned state where the magnetic disk 1 and the magnetic transfer master 2 are pressed together.

35 [0078]

Thereafter, the magnet 20 is moved in the direction shown by the arrow D and so approaches the magnetic transfer master 2. This

movement in the direction shown by the arrow D is stopped when the magnet 20 is 1 mm away from the magnetic transfer master 2. Next, the magnet 20 is moved at least once around the circumference of the magnetic disk 1 in its circumferential direction, which is to say in the direction shown by the arrow E, thereby applying the magnetic field required for transfer. By using the above-mentioned method, the pattern in the magnetic film 30 formed on the surface of the magnetic transfer master 2 is formed on the surface of the magnetic disk 1.

[0079]

Once step ST8 (magnetic transfer) has been completed, a clean robot 71 loads the magnetic disk 1 into a discharge cassette 63, and then the discharge cassette 63 is carried out from the clean booth 60, as shown in FIG. 4.

[0080]

As shown in the present embodiment, step ST7 (examination) and step ST8 (magnetic transfer) are performed together in the clean booth 60. Since the magnetic transfer in step ST8 is performed immediately after the surface of the magnetic disk 1 is examined in step ST7, no foreign matter adheres to the surface of the magnetic disk between steps ST7 and ST8. Thus, no depression damage occurs on the surface of the magnetic disk through the step of magnetic transfer.

[0081]

The present embodiment employs a configuration in which the magnetic disk 1 is placed with its surface facing upward during its carriage and in steps ST7 and ST8, but as one example, a configuration may be employed in which the surface of the magnetic disk is oriented in a vertical direction that is a direction perpendicular to the flow of air from the filter 61 in the clean booth 60. In this case, air flows in parallel to the surface of the magnetic disk 1, so that it becomes more difficult for foreign matter to adhere to the surface of the magnetic disk.

[0082]

Also, in the present embodiment, the spindle 64 and the support 6 are arranged separately. However, a configuration may be employed that allows steps ST7 and ST8 to be performed at the same position.

[0083]

Next, step ST9 (glide height test) is described with reference to FIG. 10.

A glide height test is a test where a detection head scans the magnetic disk, and defects in the magnetic disk are detected by detecting an impact. When performing this test, the clearance between the detection head and the magnetic disk is set slightly smaller than the clearance used  
 5 when a magnetic head actually scans the magnetic disk.

[0084]

FIG. 10 is a perspective drawing illustrating an apparatus for performing the glide height test in the present embodiment of the present invention. This apparatus shown in FIG. 10 includes: a spindle 21 for  
 10 supporting and rotating the magnetic disk 1 that has been subjected to step ST8 (a step of magnetic transfer); a clamp mechanism 22 that attach the magnetic disk 1 to the spindle 21; a head supporting mechanism 23 provided with a glide height test head slider 40; a guide arm 24 that supports the head supporting mechanism 23 at its base in the form of a cantilever, with  
 15 an acoustic emission sensor 25 being attached thereto; a head positioning unit 26 that moves the head 40 by moving the head supporting mechanism 23 and the guide arm 24 above the recording surface of the magnetic disk 1 to position the head 40; a positioning control unit 27 that controls the operation of the head positioning unit 26; a spindle control unit 28 that  
 20 controls the operation of the spindle 21; and a controller 29 that controls the positioning control unit 27 and spindle control unit 28.

[0085]

First, the controller 29 lets the spindle control unit 28 rotate the magnetic disk 1 at a predetermined speed. Next, the head positioning unit  
 25 26 is controlled by the positioning control unit 27 so as to move in the direction shown by the arrow F in FIG. 10 and to stop when there is a predetermined distance, which is to say 15 nm, between the magnetic disk 1 and the head 40. This position setting method is described as follows.

[0086]

When the head positioning unit 26 is in a certain position, the distance between the magnetic disk 1 and the head 40 is measured. The distance by which the head positioning unit 26 needs to move to allow the distance between the magnetic disk 1 and the head 40 to be 15 nm is then  
 30 calculated and stored in the controller 29. The controller 29 lets the positioning control unit 27 move the head positioning unit 26 and so sets the distance between the magnetic disk 1 and the head 40 at 15 nm. The distance between the magnetic disk 1 and the head 40, which is to say 15  
 35

nm, is set at a value that is equal to or lower than the distance a magnetic head floats above the magnetic disk 1 during recording and reproduction in an actual apparatus.

[0087]

5        Thereafter, while the magnetic disk 1 is being rotated, the head 40 is controlled by the positioning control unit 27 so as to move in the direction shown by the arrow G in FIG. 10, which is to say in the radial direction of the magnetic disk, to perform a glide height test for the surface that came into contact with the magnetic transfer master 2 during the magnetic  
10       transfer in step ST8.

[0088]

By doing so, unwanted protrusions present on the surface of the magnetic disk 1, and in particular protrusions that are at least as high as the clearance to be provided between the magnetic disk and a magnetic  
15       head during recording and reproduction, are detected by the acoustic emission sensor 25, based on excessive vibrational energy produced upon collisions. Thus, the presence of unwanted protrusions are detected.

[0089]

Here, when at least one unwanted protrusion is present in one  
20       magnetic disk 1, the disk is judged to be defective, and the cleaning of the magnetic transfer master 2 is started as shown in step ST2 in FIG. 1.

[0090]

When no unwanted protrusions are detected, the disk is judged to be OK, and the following step, step ST10, is performed. Step ST10 is a step of  
25       detecting defects on the surface of the magnetic disk 1, and in particular on the surface that came into contact with the magnetic transfer master 2 through step ST8 (the step of magnetic transfer). The defect detection is performed optically with respect to the surface of the magnetic disk 1 by the same method as in step ST7 in FIG. 1.

30       [0091]

When defects are found by this detection, the cleaning of the magnetic transfer master 2 is started, as shown in FIG. 1. When no defects are found, the magnetic disk 1 is installed in a hard disk drive.

[0092]

35       By performing the above-mentioned steps, highly reliable magnetic transfer can be performed, with no defects being left on the magnetic disk after magnetic transfer and signals being not deteriorated.

[0093]

This is described with reference to FIG. 11. FIG. 11 shows the results of determination of the number of defects using a commercial optical examination method and the results of signal error detection, with respect to magnetic disks subjected to magnetic transfer in a variety of magnetic disk manufacturing processes.

[0094]

Steps employed in samples 1 to 8 are shown in the time sequence from left to right.

10 [0095]

The number of defects shows an average of the number of defects calculated as a relative value when the number of defects on a standard magnetic disk that has not been subjected to magnetic transfer is taken as one.

15 [0096]

With respect to the signal errors, the signals recorded by magnetic transfer were reproduced and evaluated, the signal output achieved when reading or writing a standard magnetic disk that has not been subjected to magnetic transfer was examined, and a relative evaluation was made with ○, △, and ×, based on the number of defects where dropouts occurred.

[0097]

Magnetic transfer was performed by the method illustrated in FIGS. 5 and 6 of the present embodiment. For samples 6, 7, and 8, an optical examination using a scattered light method was performed before the magnetic transfer was carried out, and magnetic transfer was performed only for magnetic disks in which no defects had been detected. The optical examination apparatus and magnetic transfer apparatus were provided together, as shown in FIG. 4 of the present embodiment, and the magnetic transfer was performed immediately after the optical examination.

30 [0098]

In this optical examination, foreign matter was detected on the surfaces of 5% of the magnetic disks according to sample 6, 0% of the magnetic disks according to sample 7, and 0% of the magnetic disks according to sample 8. The experiments were performed in the state where the magnetic transfer master 2 had been subjected to step ST1 (a step of washing the magnetic transfer master) and step ST2 (pressing and separating of the magnetic transfer master and a cleaning disk), so that no



minute foreign matter or unwanted protrusions were present on the contact surface 3.

[0099]

As can be clearly seen from the results for sample 6, sample 7, and sample 8 in FIG. 11, it was found that when an optical examination was performed immediately before magnetic transfer, the number of defects in the magnetic disk surface after magnetic transfer and signal errors were at the same levels as those in a conventional magnetic disk on which magnetic transfer was not performed. On the other hand, as is apparent from the results for the other samples, it was found that when optical examination was not performed before magnetic transfer, both the number of defects in the magnetic disk surface and signal errors were worse than for a conventional magnetic disk.

[0100]

These results show that when foreign matter is present on the surface of the magnetic disk immediately before magnetic transfer is performed, magnetic transfer causes depression damages to occur in the surface of the magnetic disk. As shown by sample 1, sample 4, and sample 5, once depression damages occur in the magnetic disk, while it is possible to repair the defects in the surface of the magnetic disk to a certain degree through the step of tape burnishing, it is difficult to repair the disk sufficiently for signal errors to be significantly prevented.

[0101]

The reason for this is that although the rising portions around the depression portions can be removed by tape burnishing, tape burnishing does not provide an effect that allows the depression portions to be flattened out, so that spacing occurs during signal reproduction, resulting in lowered signal output that appears as signal errors.

[0102]

Furthermore, when the surface of a magnetic disk is scanned by a head for the purpose of a glide height test, head burnishing, or the like before magnetic transfer is performed, it becomes easier for foreign matter to adhere to the surface of the magnetic disk.

[0103]

That is, when in order to let a head scan the surface of a magnetic disk, the head is moved to a predetermined position, for example, a position at which the spacing between the magnetic disk and the head is 15 nm, the

head and the magnetic disk come into physical contact with each other inevitably while the head is being stabilized at the desired distance from the disk. When collisions occur between the head and the magnetic disk, the surface of the magnetic disk is damaged due to the abrasion, or powder  
5 produced by the abrasion adheres to the disk surface. This problem is becoming increasingly serious as the floating height is reduced to assist in the achievement of higher recording densities in future.

[0104]

Hence, it is preferable to eliminate the step of scanning the surface  
10 of the magnetic disk by the head before magnetic transfer.

[0105]

In FIG. 11, sample 1, sample 2, sample 3, and sample 6 represent the cases where a head scanned the surface of a magnetic disk before magnetic transfer was carried out, while sample 4, sample 5, sample 7, and  
15 sample 8 represent the cases where a head did not scan the surface of a magnetic disk before magnetic transfer was carried out.

[0106]

As also can be seen from these sample examples, in sample 1 a head scanned the surface of a magnetic disk before magnetic transfer, and while  
20 the defects caused thereby were repaired to a certain extent through the step of tape burnishing after the magnetic transfer, signal errors were not able to be restored. On the other hand, in sample 6 favorable results were obtained although a head scanned the surface of the magnetic disk before magnetic transfer was performed. This is because defects were detected by  
25 the optical examination step performed before the magnetic transfer. While the occurrence of defects was 0% for both samples 7 and 8, the occurrence of defects for sample 6 was 5%.

[0107]

From the above, it can be found that sample 7 or sample 8 that is a  
30 method described in the present embodiment is preferable as a method for manufacturing magnetic disks to be subjected to magnetic transfer. In sample 7, tape burnishing is performed after magnetic transfer, but similar evaluation results were obtained for sample 8 where this process was omitted. Accordingly, the tape burnishing step to be performed after the  
35 magnetic transfer is omitted in the present embodiment.

[0108]

According to the present embodiment described above, magnetic

transfer is performed after the steps of sputtering, tape burnishing, application of lubricant, and tape burnishing, so that the magnetic transfer can be achieved with high reliability.

[0109]

5 In the present embodiment, the surface of the magnetic disk is measured using an optical examination method immediately before magnetic transfer is performed, and the magnetic transfer is performed immediately after it has been confirmed that there are no defects in the surface of the magnetic disk. As a result, it is possible to achieve highly  
10 reliable magnetic transfer that does not cause depression damages in the magnetic disk.

[0110]

In the present embodiment, head scanning such as head burnishing or a glide height test is not performed before the magnetic transfer is  
15 carried out, so that it is possible to achieve highly reliable magnetic transfer that does not cause depression damages in the surface of the magnetic disk.

[0111]

In the present embodiment, as a method for carrying out step ST7 (optical examination) and step ST8 (magnetic transfer) together, the  
20 equipment for performing these steps are arranged inside the same clean booth. However, the method is not limited thereto. The same effect can be achieved even when two clean booths are connected each other to perform the steps, or the equipment itself is combined into one device within a highly dustproof clean room.

25 [0112]

Also, the present embodiment employs a configuration where, as shown in FIG. 4, the surface of the magnetic disk is oriented horizontally, but the disk surface may be oriented vertically so as to make it more difficult for foreign matter to adhere to the disk. In this case, when step  
30 ST8 (the step of magnetic transfer) is performed, although gravity was used in the present embodiment as means for urging the magnetic transfer master 2 toward the magnetic disk side as shown in FIG. 6, a configuration may be employed in which the magnetic transfer master 2 is urged toward the magnetic disk 1 side with an energizing spring provided between the  
35 holding arm 14 and the holding mount 16. In this way, the same effects can be obtained.

[0113]

## [Effects of the invention]

As described above, according to the present invention, magnetic transfer is performed after the steps of sputtering, tape burnishing, application of lubricant, and tape burnishing, so that the magnetic transfer  
 5 can be achieved with high reliability.

## [0114]

In the present embodiment, the surface of the magnetic disk is measured optically immediately before magnetic transfer is performed, and the magnetic transfer is performed immediately after it has been confirmed  
 10 that there are no defects in the surface of the magnetic disk. As a result, it is possible to achieve highly reliable magnetic transfer.

## [0115]

In the present embodiment, head scanning such as head burnishing or a glide height test is not performed before the magnetic transfer is carried out, so that it is possible to achieve highly reliable magnetic transfer.  
 15 [BRIEF DESCRIPTION OF THE DRAWINGS]

## [FIG. 1]

A flowchart showing steps of manufacturing a magnetic disk according to an embodiment of the present invention.

## 20 [FIG. 2]

An enlarged view of part of a magnetic transfer master, which is used for explaining the configuration of the magnetic transfer master according to the embodiment of the present invention.

## [FIG. 3]

25 A drawing showing a tape burnishing step according to the embodiment of the present invention.

## [FIG. 4]

A schematic view showing steps ST7 and ST8 according to the embodiment of the present invention.

## 30 [FIG. 5]

A cross-sectional view of an apparatus that shows the step ST8 according to the embodiment of the present invention.

## [FIG. 6]

35 A cross-sectional view of the apparatus that shows the step ST8 according to the embodiment of the present invention.

## [FIG. 7]

A drawing showing a contact surface of the magnetic transfer master

that comes into contact with the magnetic disk according to the embodiment of the present invention.

[FIG. 8]

5 A detailed drawing of a boss according to the embodiment of the present invention.

[FIG. 9]

A graph showing the relationship between the passage of time and air pressure in a space S according to the embodiment of the present invention.

10 [FIG. 10]

A perspective view used for explaining an apparatus for performing a glide height test according to the embodiment of the present invention.

[FIG. 11]

15 A table showing the relationship between various steps used for manufacturing magnetic disks and both defects and signal errors.

[FIG. 12]

A view showing a result of observation of the magnetic disk surface after magnetic transfer according to a conventional method.

[FIG. 13]

20 A cross-sectional view of a depressed portion in the magnetic disk after magnetic transfer according to the conventional method.

[FIG. 14]

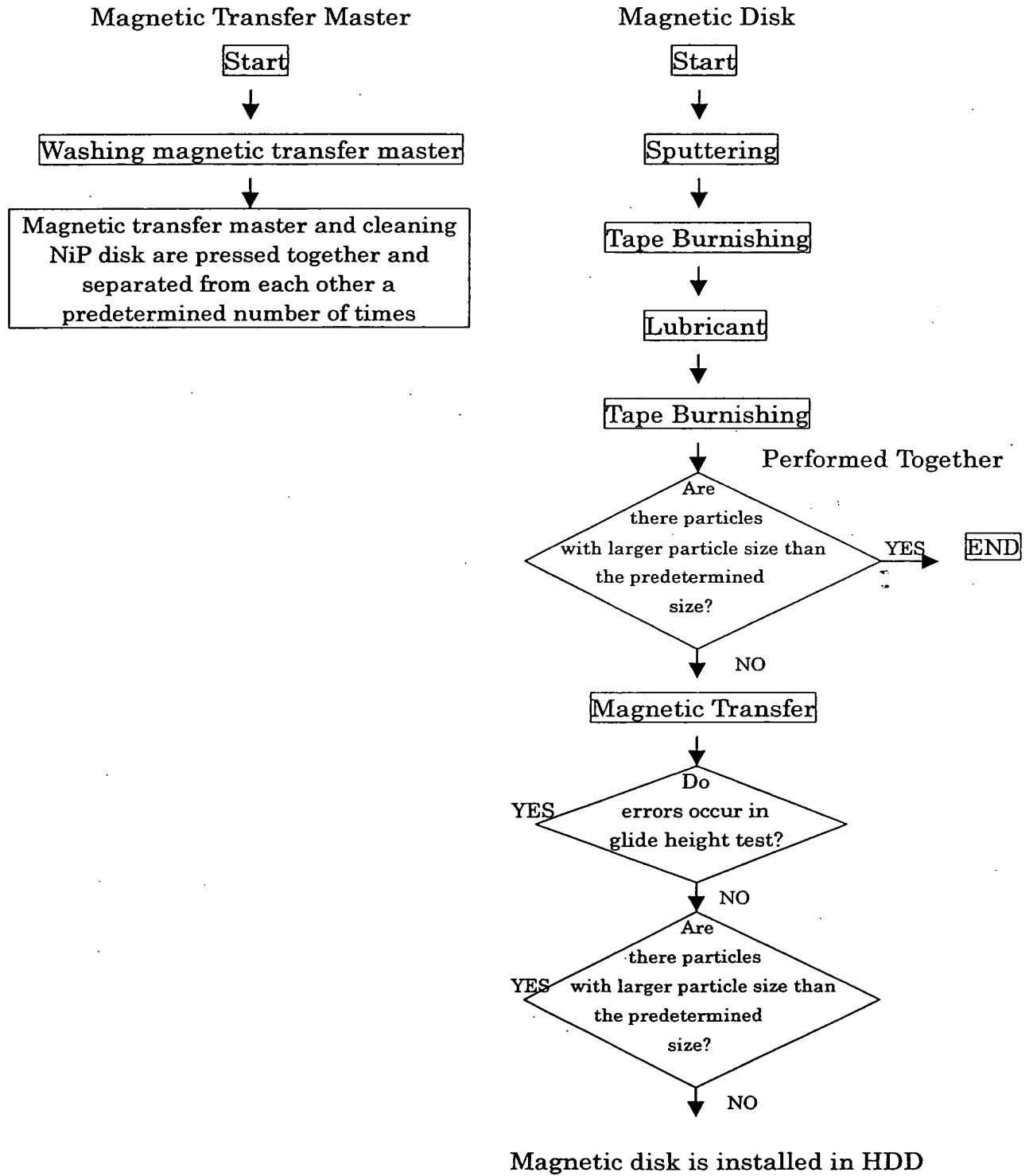
25 A depiction showing results of measurement carried out for the surface of the magnetic disk after the magnetic transfer by an optical measurement method according to the conventional method.

[Explanation of letters or numerals]

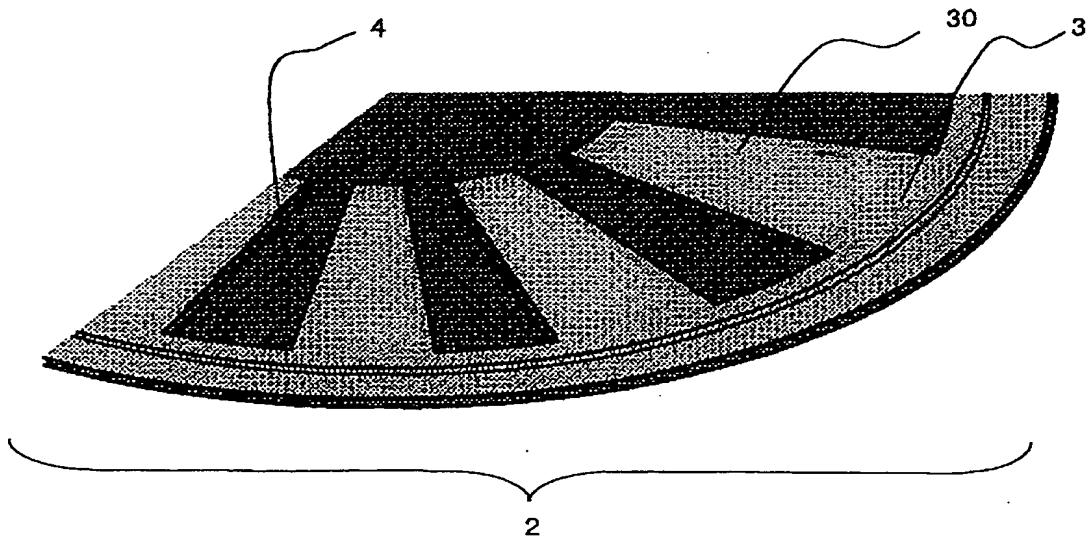
- 1 magnetic disk
- 2 magnetic transfer master
- 3 contact surface
- 30 4 groove
- 30 magnetic film

[Document Name] Drawing

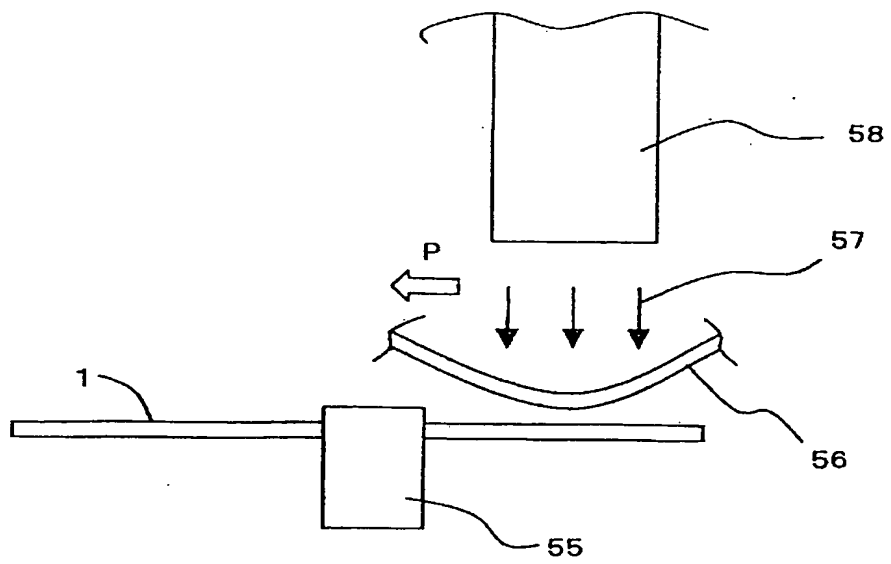
[FIG. 1]



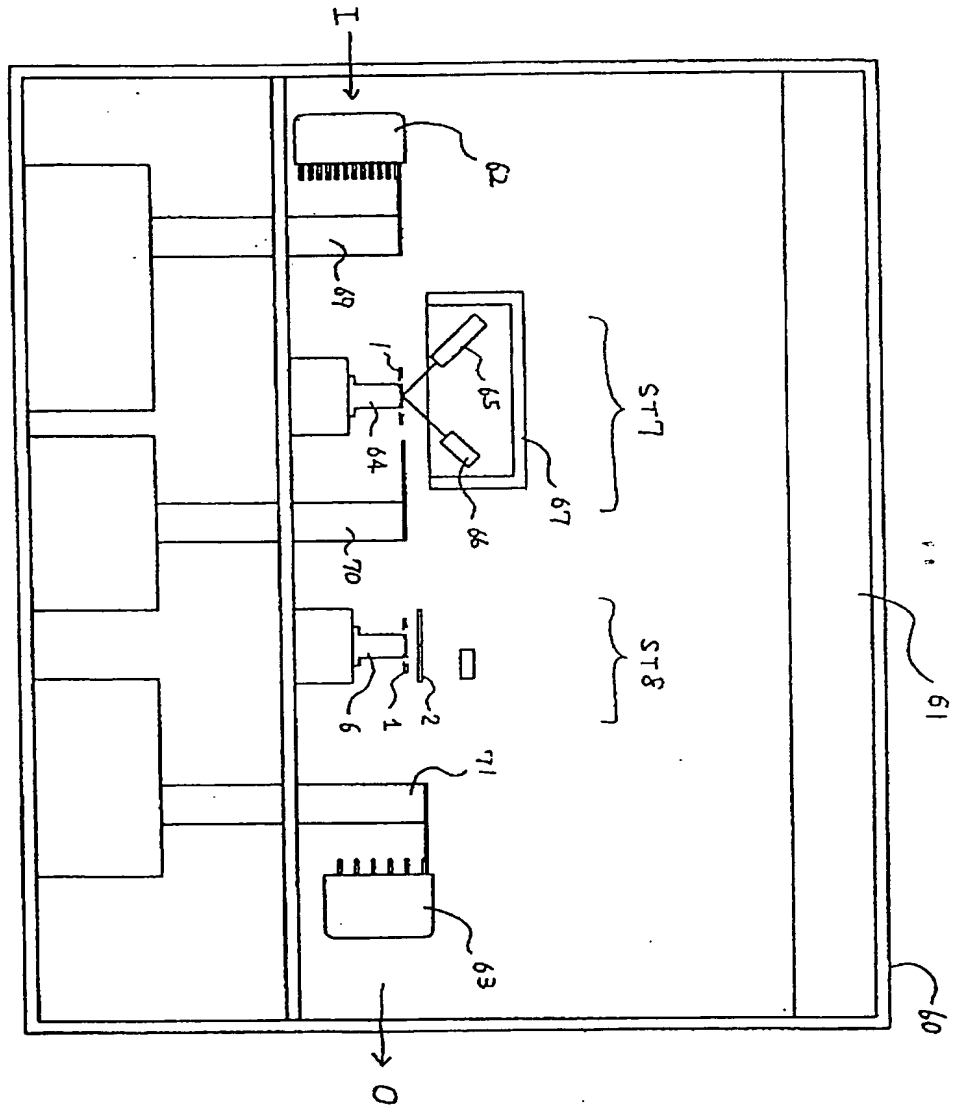
【Fig. 2】



【Fig. 3】

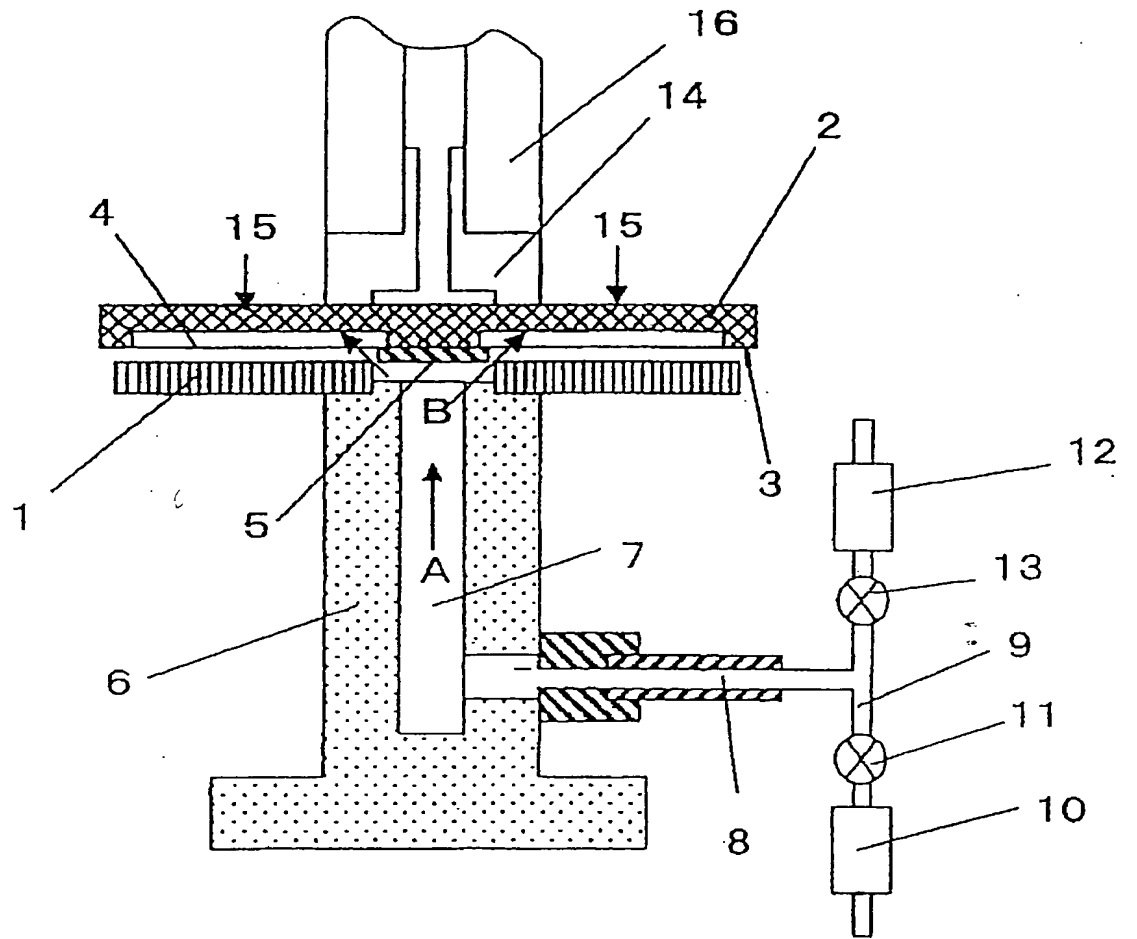


【Fig.4】

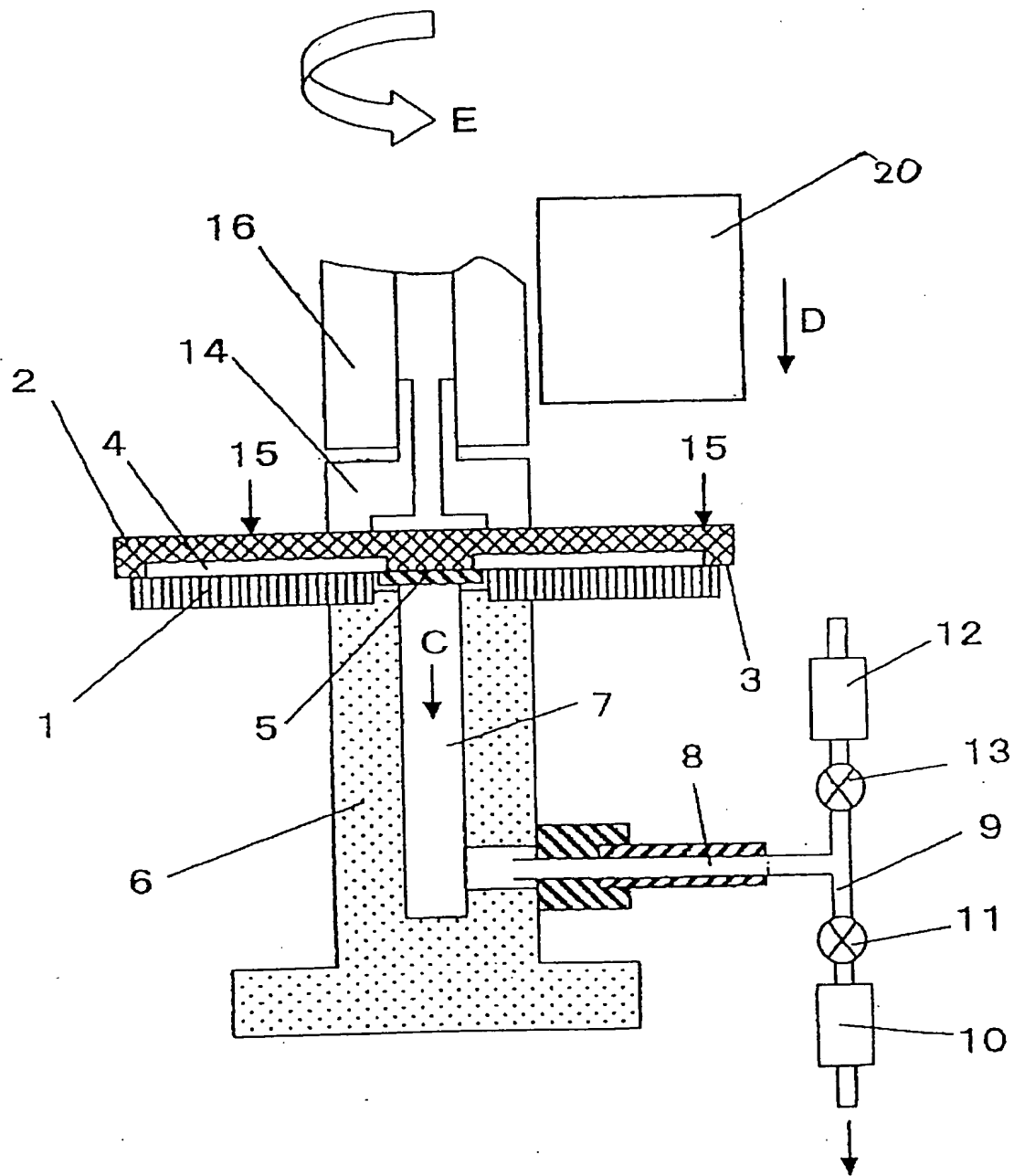




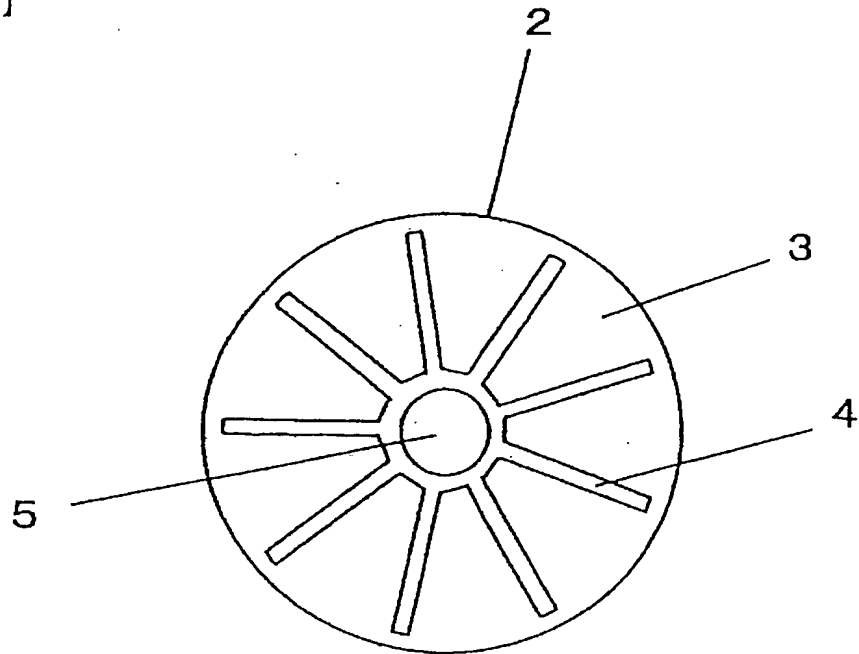
[Fig. 5]



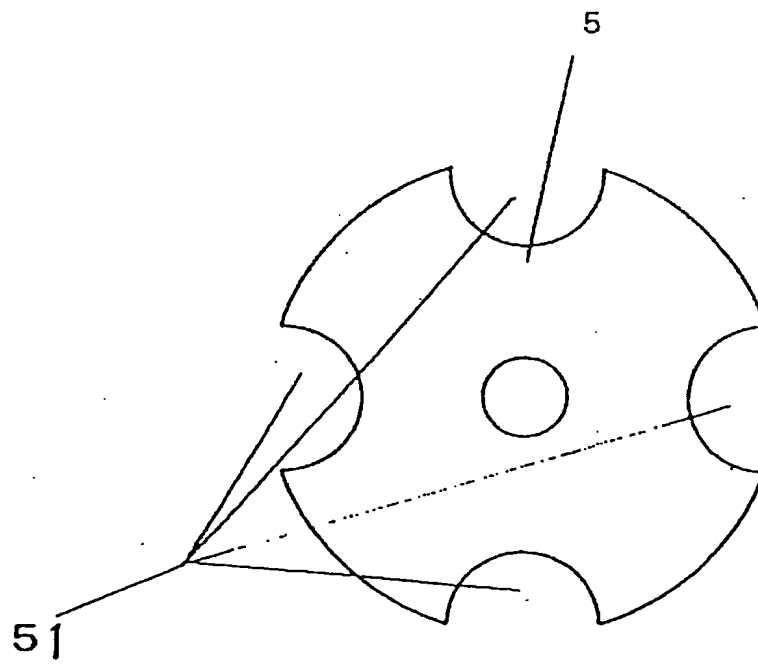
[Fig. 6]



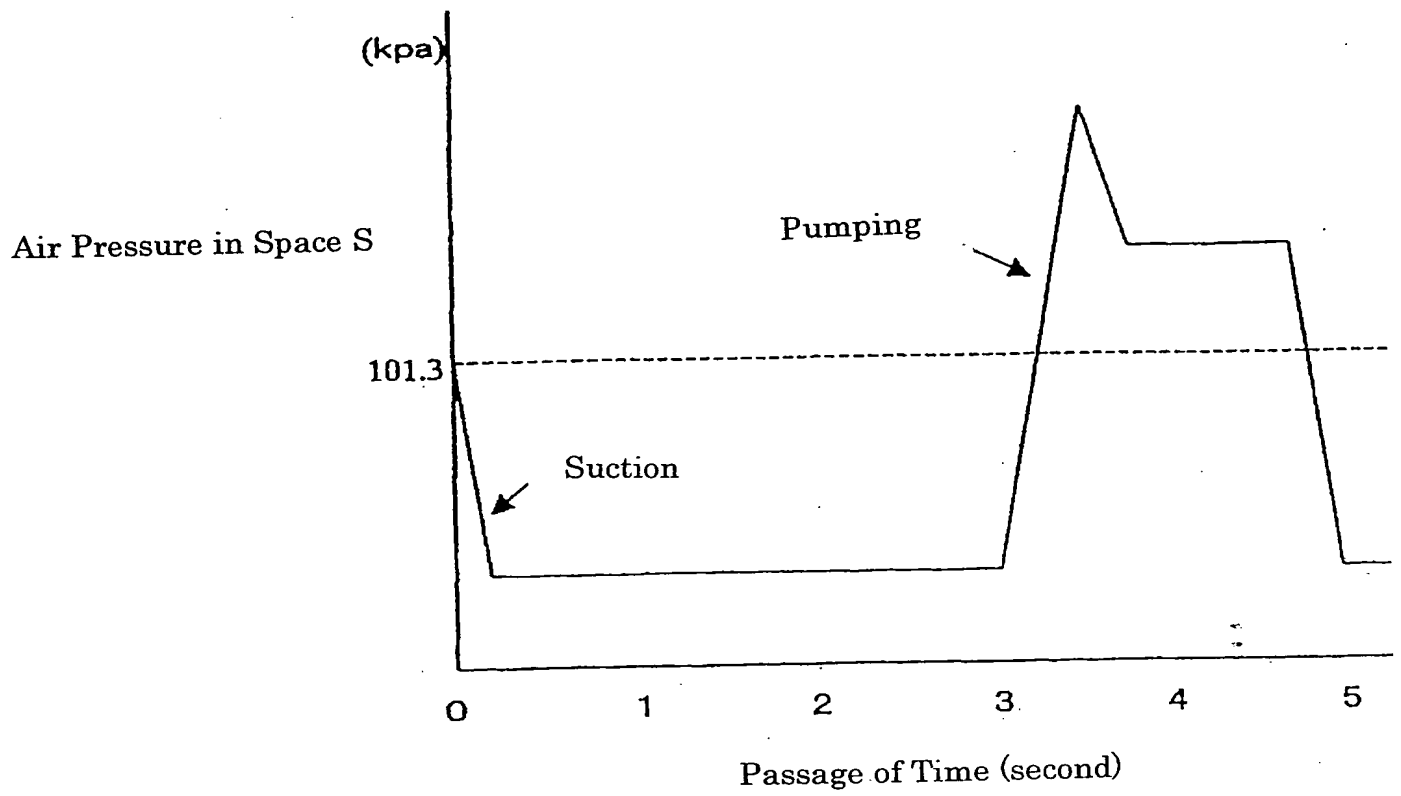
【Fig. 7】



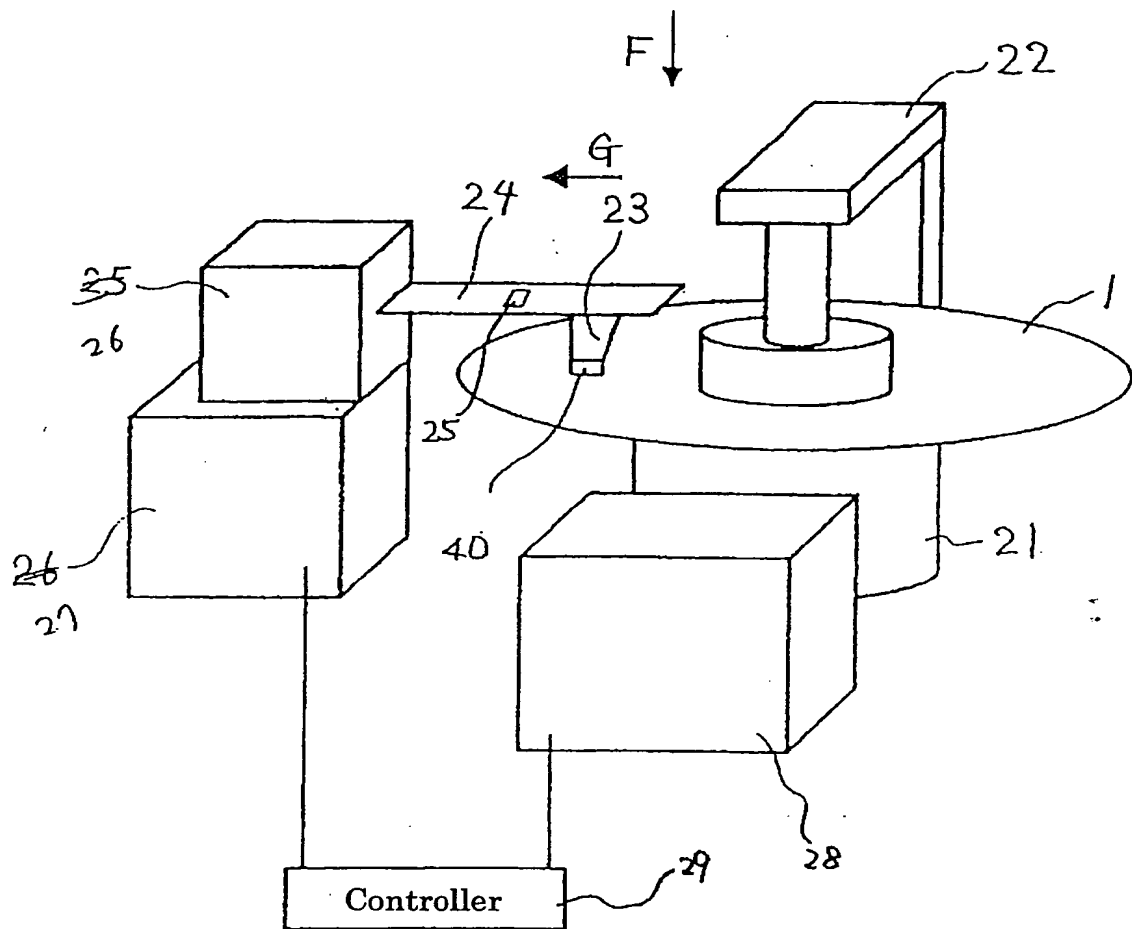
【Fig. 8】



[Fig. 9]



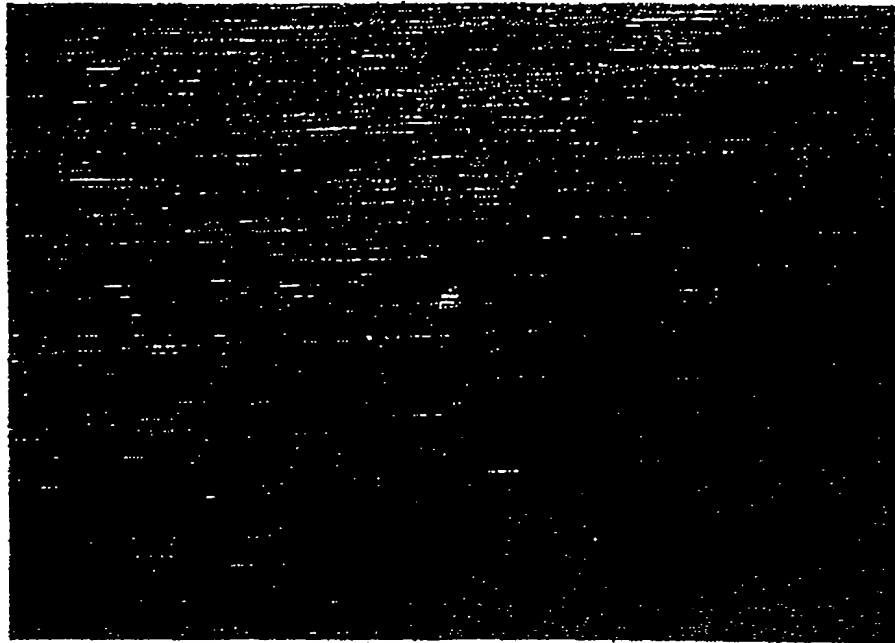
[Fig. 10]



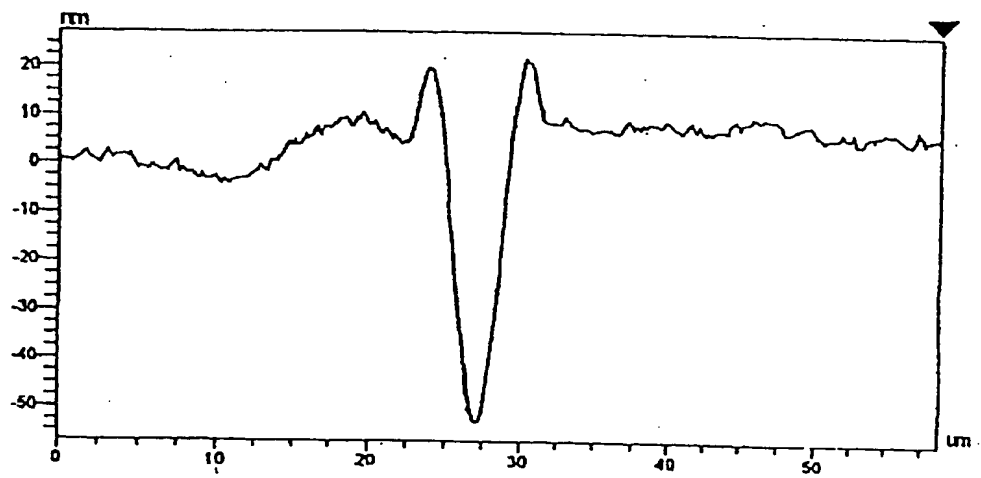
【Fig. 11】

STEPS													EVALUATION RESULTS		
														NUMBER OF DEFECTS	D.O.
1	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing	Glide Height Test	Read/Write Test				Magnetic Transfer	Tape Bur-nishing	Glide Height Test	Optical Detec-tion	1.3	△
2	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing	Glide Height Test	Read/Write Test	Tape Bur-nishing			Magnetic Transfer		Glide Height Test	Optical Detec-tion	6	△
3	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing	Glide Height Test	Read/Write Test				Magnetic Transfer		Glide Height Test	Optical Detec-tion	7.7	△
4	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant							Magnetic Transfer	Tape Bur-nishing	Glide Height Test	Optical Detec-tion	1.3	△
5	Sputtering	Tape Bur-nishing								Magnetic Transfer	Applica-tion of Lubricant	Glide Height Test	Optical Detec-tion	1.5	△
6	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing	Glide Height Test	Read/Write Test				Magnetic Transfer	Tape Bur-nishing	Glide Height Test	Optical Detec-tion	1	○
7	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing						Magnetic Transfer	Tape Bur-nishing	Glide Height Test	Optical Detec-tion	1	○
8	Sputtering	Tape Bur-nishing	Applica-tion of Lubricant	Head Bur-nishing						Magnetic Transfer		Glide Height Test	Optical Detec-tion	1	○

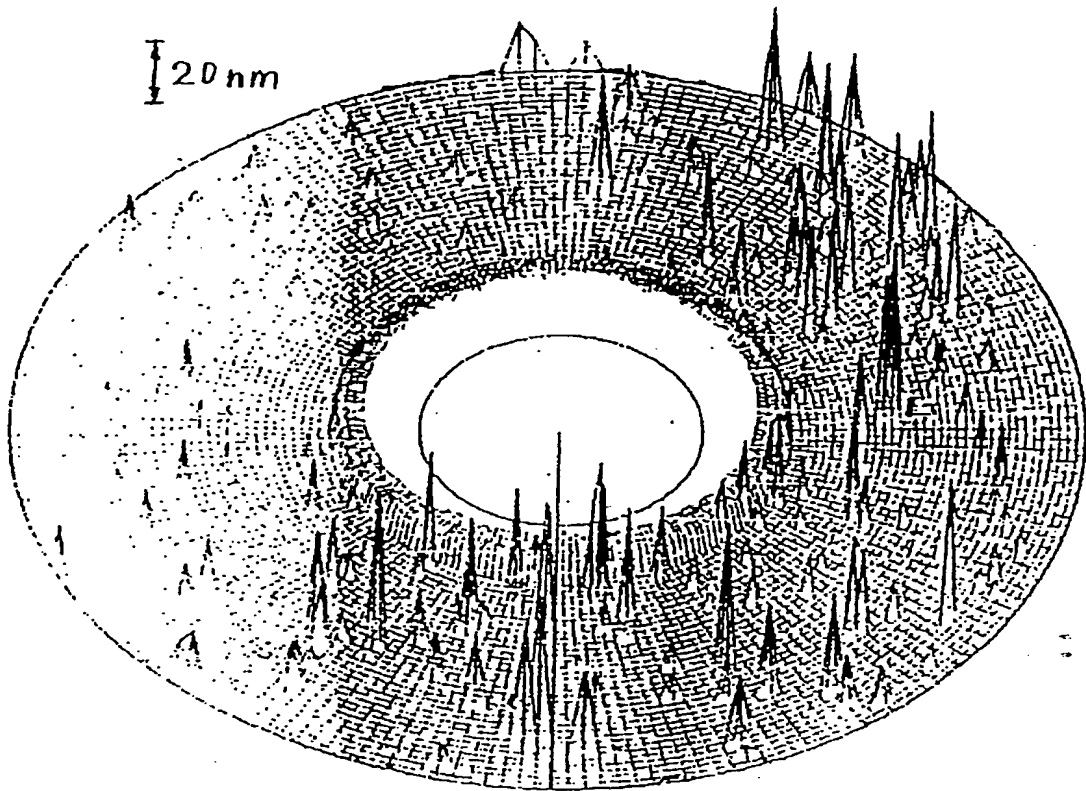
[Fig. 12]



[Fig. 13]



[Fig. 14]





[Document Name] ABSTRACT

[Abstract]

[Object] To provide a magnetic transfer method in which a magnetic disk and a magnetic transfer master are brought into physical contact with  
5 each other and thereby no minute protrusions occur in the magnetic disk.

[Means to Solve the Problems] A magnetic disk is manufactured through steps of sputtering, tape burnishing, application of lubricant, and tape burnishing, so that highly reliable magnetic transfer can be achieved.

[Selected Figure] FIG. 1